

Arizona Space Grant Consortium  
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## **PROGRAM DESCRIPTION**

The National Space Grant College and Fellowship Program consists of 52 state-based, university-led Space Grant Consortia in each of the 50 states plus the District of Columbia and the Commonwealth of Puerto Rico. Annually, each consortium receives funds to develop and implement student fellowships and scholarships programs; interdisciplinary space-related research infrastructure, education, and public service programs; and cooperative initiatives with industry, research laboratories, and state, local, and other governments. Space Grant operates at the intersection of NASA's interest as implemented by alignment with the Mission Directorates and the state's interests. Although it is primarily a higher education program, Space Grant programs encompass the entire length of the education pipeline, including elementary/secondary and informal education. The Arizona Space Grant Consortium is a Designated Consortium funded at a level of \$575,000 for fiscal year 2013.

## **PROGRAM GOALS**

The AZSGC mission is to expand opportunities for Americans to learn about and participate in NASA's aeronautics and space programs by supporting and enhancing science and engineering education, research, and outreach programs that integrate research with education to help build a diverse, scientifically literate citizenry and a well-prepared science, engineering and technology workforce. Our vision is to extend the arms of NASA--expanding our universities' capacity to conduct research and doing it in such a way that educates the next generation of scientists and engineers, all in direct partnership with industry and NASA demanding new talent and the latest innovations.

- AZSGC Management goals: Engage prominent and diverse partners to lead high quality education, research and outreach programs providing Arizonans opportunities to learn about and engage in NASA's mission and research, while benefitting our state's research enterprise and educating America's future STEM workforce.
- AZSGC Fellowship goals: Expand representation among active scientists and engineers, of our nation's diverse population. Design programs to be accessible to students from a variety of backgrounds, including those in non-technical disciplines and to improve and inform graduate and undergraduate education by providing experiences for a substantial number of students which will contribute in a number of ways, including fostering some students toward professional careers in aerospace science and technology, while also fostering understanding, appreciation and sensitivity to space science and engineering as important national endeavors.

- AZSGC Research Infrastructure goal: Sponsor innovative programs in space science/engineering focused research and design, with associated opportunities to apply classroom knowledge to real-world, NASA-focused problems.
- Higher Education goals: Recruit and support a diverse group of participants, promote initiatives to develop interdisciplinary courses/curriculum and teacher training, sponsor group educational activities for Interns, Fellows and others to complement and enhance student learning, to foster a sense of community by building linkages and promoting networking among students, faculty, researchers, industry professionals and the public, and to provide a diverse group of students opportunities for educational/professional growth and promotion.
- Precollege goals: Attract and retain students in STEM disciplines through a progression of educational opportunities for students, teachers and faculty with special focus on training STEM educators—not only to excite and inspire P-12 students—but to excite and inspire while instilling basic competencies to insure that AZ students are prepared and able to study science in college.
- Public Programs goals: Engage members of the public from traditionally underrepresented groups, bridge the gap between Earth systems science research, geospatial technology and societal needs in Arizona, leverage funding to extend the reach of Space Grant beyond direct investment, support science education needs in underserved areas of our state, engage our students in informal education initiatives and track impacts and evaluate programs success via quantitative and qualitative methods (plus longitudinal tracking of graduate fellow/undergraduate intern participants) to insure continuous process improvement.

### **PROGRAM/PROJECT BENEFIT TO OUTCOME (1, 2, & 3)**

For succinctness, throughout this report NASA Education Outcomes and Education Priorities are referred to by number: Employ and Educate as Outcome 1; Educate and Engage as Outcome 2; Engage and Inspire as Outcome 3; Hands on student experiences as NEP1; Middle school teachers as NEP2; Summer opportunities for secondary students as NEP3; Community colleges as NEP4; Aeronautics research as NEP5; Environmental Science and Global Climate Change as NEP6; Diversity as NEP7; and Innovative research infrastructure as NEP8.

AZSGC has become a catalyst for synergy between NASA, industry, and Arizona's education/research efforts. Programs extend the arms of NASA—expanding our universities' capacity to conduct research and doing it in a way that educates our next generation of scientists and engineers, directly contributing to Outcome 1 while also addressing NEP1, NEP4, NEP5, NEP6, NEP7 and NEP8.

We use our presence at universities and partnerships with Arizona research organizations, federal research labs, and industry, to integrate smart, motivated students into current research programs and missions, which serve as ideal "classrooms" for training the next generation of aerospace professionals, and then leveraging student research into outreach designed to promote the understanding of NASA-related research to precollege audiences and the public (Outcomes 2 and 3). Simultaneously, researchers get student workers at an

affordable cost, which in turn extends research program capabilities, learning and accomplishments. Integrating students into leading-edge research programs serves as a launchpad into our nation's STEM workforce and top graduate programs (Outcome 1). Select FY 2013 examples (representing many more) are:

**Outcomes 1, 2, and 3 (NEP1, 4, 6, 7, 8):** Marianna Yanes, a two-year (FY 2011, 2012) Arizona Space Grant Intern/Intern Advisor, and a first-generation college student, was one of only two University of Arizona (UA) undergraduate students selected to receive a prestigious Arizona Centennial Achievement Award at the Fall 2013 Commencement ceremony on December 21, 2013. Awardees are selected for their “integrity, achievements and contributions to their families and community.” Marianna, who received her BS degree in Biosystems Engineering, grew up in Sonora, Mexico, and moved to Arizona when she was seventeen. In the United States, she attended a high school where all classes were taught in English—a monumental challenge. With perseverance, she mastered class content, graduated, and was admitted to UA. At UA she found a home in Space Grant; many of her notable university achievements were gained through her two-year participation in the Undergraduate Research Internship Program, where she found her niche and passion working on the UA/NASA Space Grant Steckler II Lunar Greenhouse (LGH) Development team. She was responsible for the day-to-day operations of the LGH system's performance and energy balance studies, the daily remote monitoring of operations of the LGH-Outreach Teaching Module while it was on display at the Chicago Museum of Science and Industry (July 2012-January 2013), and served as an Intern advisor to two LGH Space Grant Interns from Pima Community College and others. In addition, she led countless LGH tours for schools, community groups, scientists and other interested individuals--and was able to provide tours in both English and Spanish. Marianna has been offered a full scholarship to graduate school at the UA and has received similar offers from other universities. She plans to enter graduate school in the fall of 2014 and ultimately build on her Space Grant LGH experience and start her own greenhouse company to help fight hunger on Earth in a sustainable, environmentally responsible way.

**Outcomes 1, 2, and 3 (NEP1, 7, 8):** Paula Johns moved from place to place as a child--growing up in Mexico, China and the US—but maintained a steadfast dream: to become the first member of her family to pursue a graduate degree en route to becoming a brilliant, Mexican-American researcher for NASA, and perhaps even a member of the astronaut corps. We are proud that AZSGC has played a significant role in propelling her towards these goals. In FY 2011, Paula, then a Physics/Astronomy junior, was awarded a NAU Space Grant Undergraduate Research Internship to work at Lowell Observatory with mentor Dr. Lisa Prato, researching “The Formation and Evolution of Binary Stars.” She loved the work, and became such an integral part of Dr. Prato's research team that she was hired to continue her Lowell research for the duration of her undergraduate career. While working as an Intern, she maintained a stellar GPA, and made time to tutor precollege students in the math and sciences, serve as vice-president of the NAU Astronomy Club, become a certified telescope operator for the Atmospheric Research Observatory, and volunteer her Friday nights to running and managing the Atmospheric Research Observatory for public viewings. Paula received many well-deserved awards

and accolades commemorating her hard work and accomplishments: the Physics/Astronomy Chair's Scholarship for excellence in physics, the National Society of Collegiate Scholars scholarship and honors, the Northern Arizona University President's Scholarship, Katie's Gift (a scholarship for students with a passionate and career-focused interest in astronomy), and was on the Northern Arizona University Dean's list every semester of her undergraduate career. She graduated from NAU with honors in May 2013, and began a PhD Astrophysics graduate program at University of Toledo this fall.

**Outcomes 1, 2, and 3 (NEP1, 7, 8):** AZSGC appreciates that it “takes a village” to build, sustain and grow the NASA STEM education pipeline. One way we accomplish this is by nurturing student educational and professional growth in college through involvement in leading edge, mentored, NASA-focused research. Our ASU Space Grant program goes a step further, leveraging program resources and maximizing reach by asking student researchers to serve as role models by providing at least 20 hours of high quality STEM outreach to precollege students and others as a part of their Space Grant awards. Managers, steering committee members, and research mentors also contribute. In one example, “full-circle” ASU faculty member and Space Grant Graduate Fellow Alumnus Joseph Foy (FY 2002-2005), serves on the ASU Space Grant Steering Committee and helps select Space Grant Interns and Fellows. Joe is also the faculty advisor for ASU's “Science Detectives,” a volunteer-funded student club. Club members are a diverse group of 52 undergraduates who lead a fun and engaging after-school science program that has served over 800 elementary students from 7 different schools through weekly lessons with hands-on experiments to solve “mysteries”, while exploring real-world applications of physics, biology, chemistry, and mathematics. Space Grant managers help advertise “Science Detectives”; this year three Space Grant Interns are participating. One of these, ASU 2013 Space Grant Undergraduate Research Intern Stephanie Maxwell, is not only a high achiever in her Space Grant mentored research with Dr. Jeffrey LaBelle, (“Stephanie is one of the best undergraduates I have ever mentored. She has presented to the Assistant Secretary of Defense, at two international conferences, and continues to impress me”), but she also serves as Organizational Chair of “Science Detectives”, responsible for communicating with teachers/schools, recruiting and interviewing prospective members, matching volunteers with teams and establishing school placements, providing training and supplies for class sessions, writing grants, and evaluating program accomplishments each semester. In addition, she is an extraordinary “Science Detective” who leads or participates on teams at three local elementary schools, a Child Crisis Center, and leads science-focused lessons for general public audiences at Crisis Center fundraisers. Although the program has received glowing reviews from students, parents and teachers alike (one wrote “Your program meets an important need for younger elementary students in such a fun, memorable way”), university outreach providers have found that achieving classroom access is challenging. In response, the ASU Space Grant Associate Director and Coordinator worked to systematically meet and build relationships with local school district personnel. They established formal partnerships with the large Tempe Elementary District 3 (close-by to ASU with many Title 1 schools), the Tempe Union High School District, and have engaged the district's overall Science Coordinator to help facilitate the reach of “Science Detectives” and other Space Grant Intern and Fellow outreach programs into local elementary, middle, and high schools of greatest need. In keeping with “it takes a village” and NASA's commitment to

building partnerships, the ASU Space Grant team is effectively working to sustain and grow the NASA STEM education pipeline in Arizona, while taking a popular and well-reviewed STEM outreach program to new heights.

## PROGRAM ACCOMPLISHMENTS

**Fellowships Programs:** In FY 2013, AZSGC sponsored 6 Fellowship programs directed to Outcome 1, with select Internship and all Graduate Fellowship projects also contributing to Outcomes 2 and 3. Programs are designed to address Fellowships goals (above); 2013 accomplishments are measured against SMART objectives below:

1. **Support  $\geq 87$  students:** There were 137 Fellowships/Scholarships awarded to 124 undergraduates and 13 graduate students.
2. **Support a diverse group of students with at least 24% from underrepresented groups:** Of the total awards, 37 (27%) went to students from underrepresented minorities.
3. **Support 45% women:** Of 137 awardees, 66 (48.2%) are female.
4. **Support students from diverse academic backgrounds representing  $>30$  majors:** 2013 students reported 39 distinct academic majors.
5. **Promote quality outreach and community service programs with contributing partner organizations:** AZSGC supports 13 Graduate Fellows who designed and implemented programs, and 45 ASU Interns contributed 20 or more hours to STEM outreach in local schools or other public venues delivered through precollege, higher education, and informal education components, which gave many others opportunities to participate in NASA's science, engineering and education (Outcomes 1, 2, 3).
6. **Support mentored (NASA-focused), Undergraduate Research Internships with Arizona, NASA and industry researchers:** There are 124 Undergraduate Research Interns from UA, ASU, NAU, ERAU, and Pima Community College (PCC) from a variety of backgrounds and technical and non-technical disciplines, who are receiving mentored, hands-on professional work experiences on university campuses, in local industry and at NASA Centers, focusing on science/engineering, education, journalism and science policy (Outcomes 1 and 2).
7. **Program participants and their research will generate  $>10$  professional publications, presentations and proposals:** Science writing interns wrote 14 articles for two major AZ newspapers. AZSGC authors published 37 research articles, 16 authors submitted papers not yet published, 11 invited papers, and 17 self-submitted papers with a review process were supported by Space Grant Fellowship efforts. 26 proposals were submitted and to date, 8 have been funded with a value of \$3,238,000.
8. **Evaluate programs' success via quantitative and qualitative methods to ensure continuous process improvement:** Participants will complete written program evaluations, Graduate Fellows will make formal outreach program review presentations to steering committee members and interested members of the university community, and student tracking records were generated and will be updated for all program awardees.

9. **85% of program graduates will pursue advanced degrees in NASA-related STEM fields, and/or join the nation's STEM workforce:** Of 957 (total) AZSGC 2006-2013 Fellowship/Scholarship significant award recipients: 691 have completed degree programs, 29 seeking STEM employment are considered "still-to-be tracked". The remaining 662 have taken next steps, and of these, 625 (94%) are now employed in STEM fields or are pursuing additional STEM degrees (see Tracking below).
10. **Leverage program funding:** AZ/NASA Space Grant Fellowships funds (\$263,752) are highly leveraged with Arizona dollars (\$214,882), and approximately (\$61,303) of other federal cost sharing.

In total, AZ Fellowship programs directly addressed NASA Education Outcomes 1 with Outcomes 2 and 3 addressed through Intern community service, and through major Graduate Fellowship outreach programs conducted with a wide variety of cost-sharing stakeholders and educational partners. NASA priorities and current areas of emphasis (NP1, 4, 5, 6, 7, and 8), and all goals and SMART objectives were met and exceeded.

**Research:** In FY 2013 to date, 180 students participated in 16 AZSGC sponsored Research programs directed to Education Outcome 1. In addition, several programs have Precollege and Informal Education components contributing to Education Outcomes 2 and 3 (ASU Robotics, Daedalus Astronautics, ERAU Rocket Challenge, etc.). *It should be noted that data in this progress report, collected earlier than in recent years, reflects fall semester accomplishments; a balloon-sat program at Dine Tribal College scheduled for April 2014 will bolster participants diversity.* Programs are designed to address the Research goals (above) and 2013 accomplishments are measured against the SMART objectives below.

1. **Support 30% diversity:** There are 180 participants (17.2%) from under-represented ethnic/racial groups; 52.3% of funded students are underrepresented.
2. **Support 45% women:** Of 180 students, 35 (19.5%) are women.
3. **Sponsor >6 multi-disciplinary, student led and directed team engineering programs:** AZSGC supported 14 team projects including 1) A statewide balloon satellite program, ASCEND! (UA, ASU, ERAU, PCC, SMCC, GCC; Diné will participate in ASCEND! activity in April 2014); 2) Lunabotics (ASU); 3) Robotics Team Projects (ASU); 4) Daedalus Astronautics Rocketry Team (ASU); 5) SunDevil Sat 1 (CubeSat) development (ASU); 6) NASA Reduced Gravity (ASU); 7-8) HASP (ASU, ERAU); 9) EagleSat (Cubesat) development (ERAU); 10) SWE Moonbuggy (ERAU); 11) CanSat (ERAU); 12) HiBal (ERAU); 13) Rocket Challenge Competitions (ERAU); and 14) Cyclotron (ERAU).
4. **Build relations with NASA and aerospace industry:** Research and design programs 2, 3, 4, 5, 6, 7, 8, 9, and 10 (Objective 3 above) were conducted in direct partnership with NASA centers and aerospace industry
5. **Grow ERAU and ASU R&D by at least 2 programs over 5 year grant cycle:** ASU and ERAU have supported 6 new team engineering programs since 2010.
6. **Support at least 5 teams in a statewide balloon-sat program:** 6 college and university teams (including 3 MSIs/HSIs) participated in "ASCEND!" our statewide balloon satellite program in 2013 with opportunities to experience the

- full design-build-fly-operate-analyze cycle of space missions; 40 undergraduate students participated during fall semester with some additional participants expected to join in the spring. All participants will present the results of their flight experiments in a dedicated “ASCEND!” session at our Statewide Symposium in April 2014 (see Higher Education). For the first time in spring 2014, we are taking a balloon-sat build/launch/chase down activity “on the road” to remote Diné (Tribal) College, to give students and instructors a chance to participate in the learning and excitement of ASCEND!, bringing a 7<sup>th</sup> team to statewide balloon-sat activities (see Minority Serving Institutions).
7. **Promote NASA-focused astronomy learning, hands-on education and research through the 15 colleges/universities National Undergraduate Research Observatory consortium (NURO):** NAU SG provided small travel grants/reimbursements for 23 students from NURO, competitively selected to travel to Arizona with mentors, and observe on a 31-inch telescope owned by Lowell Observatory/administered by NAU; to date in FY 2013, 3 authors published scientific work.
  8. **Leverage program funding:** AZ/NASA Space Grant Research funds (\$37,000) are leveraged with Arizona dollars, bringing an additional \$7,750 to these workforce development programs in 2013 (funding for some student participants is reported in Fellowships above).

Cumulatively, programs help foster relations with NASA centers and aerospace industry, while directly contributing to Outcomes 1, 2, and NEP1, 4, 6, 7 and 8. All programs met the AZSGC Research goal of providing authentic, hands-on student (team engineering, research, and design) experiences rooted in NASA-related topics and incorporating real-life problem-solving and needs with a strong workforce development focus. All program area SMART objectives were met with the exception of objectives 1 and 2; we did not achieve the desired levels of ethnic/racial or gender diversity of overall participants. We far exceeded objectives for ethnic/racial diversity of direct funded students.

**Higher Education:** In FY 2013, AZSGC sponsored 11 higher education programs directed to Education Outcome 1, with 1242 student participants. Programs are designed to address the Higher Education goals (above) and accomplishments are measured against the SMART objectives below:

1. **Support 30% diversity:** A total of 475 participants (38%) are from underrepresented groups.
2. **Support 45% women:** Of the 559 students (45%) are female.
3. **Include 5 minority serving institutions/initiatives:** PCC, SMCC, GCC, TOCC and Diné participated in programs.
4. **Support  $\geq 5$  multidisciplinary group activities:** Supported activities are: 1) SEDS research, promotion, preschool and community outreach (UA); 2) Statewide Symposium (UA, ASU, NAU, ERAU, SMCC, PCCC, GCC); 3) Multidisciplinary courses (UA, ASU, SMCC, GCC, PCC); 4) International Asteroid Search training/participation (Diné); 5) Supplementary educational activities for UA Space Grant Community members: to date, a tour of Steward Observatory’s Mirror Laboratory, and a private Space Grant Show at Flandrau Planetarium have occurred; scheduled for later in spring 2014 are: brown-bag

- lunch events with guest speakers, and a behind the scenes tour of Biosphere 2 (UA); 6) Abstract and PowerPoint presentation development training workshops (UA, ASU, NAU, PCC); 7) Campus STEM outreach and program promotion events (ASU, NAU); 8) Women in Physics Conference (NAU); 9) Workforce Development Through Geospatial Literacy (UA); 10) STEM Courses Enhancement (TOCC); and 11) Undergraduate Research Day at NAU in spring 2014, will provide NAU Interns and others a venue to present research posters to campus peers, faculty and local industry professionals.
5. **Host a statewide Undergraduate Research Internship Symposium:** In April 2014, the Twenty-Third Annual Arizona/NASA Statewide Undergraduate Research Internship Program Symposium will be held, with students presenting on academic year-long research projects relevant to all NASA Mission Directorates.
  6. **ASU outreach for recruiting:** On February 26, 2014, Interns will showcase their research to the campus community via a professional poster session. They will also present hands-on demonstrations of Mars terrain, water-bottle rockets, underwater robots, make low-frequency cosmology demonstrations and more at the School of Earth and Space Exploration's Earth and Space Exploration Day, and act as docents in the Gallery of Scientific Exploration in ASU's new Interdisciplinary Science and Technology building (Objective 4 project 7).
  7. **Support multidisciplinary course development:** Revised Space Grant activity-focused courses were offered at UA, ASU, PCC (HSI), SMCC (MSI), and GCC (HSI).
  8. **Develop/support opportunities to network and promote linkages between Space Grant students, faculty, researchers, industry and NASA professionals to foster workforce development, educational/professional growth and promotion:** Higher Education programs 1-10 (Objective 4 above) promoted linkages, networking and enhanced student workforce development, educational/professional growth and promotion. To date in FY 2013, 2 authors published work, 6 authors have publications in press, 4 presented invited papers at professional meetings, and 5 proposals were submitted with 3 funded for a total value of \$3,284,711 associated with AZSGC Higher Education programs.
  9. **Leverage program funding:** AZ/NASA Space Grant Higher Education funds (\$108,660) are highly leveraged with Arizona dollars, including Geospatial Specialist Barron Orr committing 5% FTE (\$5,776) to programs at no charge to our grant, bringing an additional \$74,162 to these workforce development programs in 2013.

These activities and others, contribute directly to AZSGC Higher Education goals and objectives, and to Education Outcomes 1, 2, 3 and NEP1, 4, 5, 6, 7, and 8. All program area SMART objectives were met or exceeded.

**Precollege:** To date in FY 2013, AZSGC sponsored 14 Precollege programs that cumulatively have served 223 formal and informal educators and 3,882 Arizona precollege students. The majority of activities are conducted in collaboration with partners to leverage funding and to extend reach; 10 programs were designed and



delivered by UA and ASU Space Grant Graduate Fellows. Most programs address multiple AZSGC goals/objectives, and all contribute to NASA Education Outcome 2 (Educate and Engage). Programs are designed to address the Precollege goals (above) and accomplishments are measured against the SMART objectives below:

1. **Programs align with Arizona and National Standards:** All supported programs align with state and national standards.
2. **Direct programs to underrepresented/underserved groups and areas of greatest need:** According to the 2011 U.S. Census, Arizona's population includes 30.1% Hispanics and 5.2% American Indians. In 2010, Science Foundation Arizona reported that a mere 2% of Arizona's minority population pursued and graduated with STEM degrees. AZSGC is committed to addressing this serious shortcoming; 9 of 15 FY 2013 AZSGC precollege programs serve reservation or other schools with high underrepresented enrollments. These include two NASA-focused programs serving reservation schools/teachers/communities including: 1) The "Navajo-Hopi Outreach program" with affiliate Lowell Observatory that delivers hands-on NASA space science content, educational activities, field trips and guest presenters to 4 Navajo and Hopi reservation schools and 14 teachers and 155 students (NAU); 2) The "American Indian Mobile Education Resource (AIMER)" traveling science classroom and educators, delivered NASA Space Science educational resources, lessons, and activities to 9 elementary school teachers and 287 students and 6 middle school teachers and 23 of their students at rural reservation schools (NAU). Six graduate-fellow led programs serve schools with large underrepresented populations including: 3) "Space to Soils", a curriculum development project, carried out in partnership with the NSF i-STEM program that employs in-school, hands-on science activities and informal, out of classroom science field trips to stimulate STEM interest and learning in 3-8 grade students; i-STEM has a strong focus on evaluating the program's effectiveness on Native American and Hispanic student academic performance and retention (UA); 4) "Expanding the scope and accessibility of Mt. Lemmon Sky Center", delivers an immersive Earth and Space Science experience for 105 primarily underrepresented/underserved elementary and high school students from economically challenged backgrounds and 13 teachers (UA); 5) "Solar Energy Sports" (UA), 6) "Teaching and Learning through a School Reconciliation Ecology Program (UA), and 7) "Operation Soar" (UA); 8) Earth Science "Erosion and Rivers" Retreat at Tonzona field courses (ASU); and 9) Interns' precollege outreach activities, are largely directed to schools with high percentages of underrepresented/underserved students (ASU).
3. **Programs support NASA Education:** All Native American and underserved-directed programs 1-9 (Outcome 2 above) focus on NASA research topics, and incorporate NASA curricular materials and/or expertise. In addition, 10) GEMS, a workshop, scheduled for March 28-29, 2014 for 6-8<sup>th</sup> grade teachers—many recruited from reservation schools—will use NASA content to help build educator confidence for teaching Space Science topics (NAU); 11) an ASU Space Grant Grad Fellow's curriculum development for the Center for Meteorites Studies, (ASU) 12) "Teaching the electromagnetic spectrum using hands-on activities (ASU); and "Applications-based, interactive STEM Problem Solving Seminars at

Tempe Union High School District” schools (ASU) all incorporate NASA content. 13) “Middle School Science Clubs” (NAU); and 14) “Rocket Challenge”, a summer campus program for secondary students (ERAU), also integrate NASA material.

4. **Programs engage middle school teachers in hands-on curriculum enhancement:** See programs 1, 2, 8, and 10 (objectives 2 and 3 above).
5. **NASA education and outreach provided to remote reservation schools via AIMER:** See programs 1, 2 above.
6. **Leverage program funding:** FY 2011 AZ/NASA Space Grant Precollege funds (\$39,500) are highly leveraged with Arizona (\$10,224) cost sharing dollars.

These and other Precollege activities contribute directly to AZSGC goals and objectives and to NASA Education Outcomes 1, 2, 3 and NEP1, 2, 3, 6, 7 and 8. All program area SMART objectives were met.

**Informal Education:** In FY 2013, AZSGC sponsored 10 Informal Education programs, most in collaboration with partnering organizations to leverage resources and to extend reach. Five are led by Space Grant Graduate Fellows. To date in FY 2013, these programs have 23,014 participants. Our flagship effort, the Earth Grant Geospatial Extension Program, is designed to bridge the gap between NASA Earth Systems science and technology and its use by the general public through a strategic partnership between Land Grant (Cooperative Extension) and Space Grant in Arizona. Led by the UA Space Grant Associate Director at no charge to our grant, guiding a cadre of Graduate Fellows, Undergraduate Research Interns and representatives from partnering programs and agencies who collaborate to address shared program goals and sponsor a variety of activities, Earth Grant promotes STEM literacy and enhanced linkages between formal and informal education. The program focuses on capacity building, scientific literacy and STEM learning. FY 2013 projects land in three general categories: (1) technology transfer, (2) precollege afterschool programs that want to use NASA science and technology for STEM learning, youth empowerment, civic engagement and the promotion of healthy life styles, and (3) knowledge transfer associated with the science behind desertification and its control. Earth Grant and other Informal Education programs, address multiple AZSGC goals/objectives and NASA Outcomes 2 and 3. Programs are designed to address the Informal Education goals (above) and accomplishments are measured against the SMART objectives below:

1. **30% diversity of participants:** Demographic data are only routinely collected for programs conducted under the Earth Grant Program. Overall, Earth Grant activities directly engaged 20 informal educators and 1,350 general public participants with 34.9% traditionally underrepresented in STEM (higher education student participants are reported in that reporting area).
2. **45% female participation:** Gender diversity data is only routinely collected for Earth Grant programs, which have directly engaged 56.6% female participation.
3. **Serve >12 communities with Earth Grant programs:** Programs and activities were conducted in 14 Arizona communities in 2013.

4. **Train AZSGC students/informal educators to help deliver >4 NASA Earth science focused topical training sessions:** Earth Grant activities directly engaged 20 informal educators in 19 public at large Earth science educational activities.
5. **Build strategic partnerships with formal and informal STEM education providers:** Earth Grant activities are conducted in partnership with Cooperative Extension and numerous community organizations, schools, tribal groups, government agencies and businesses. NAU Space Grant participates in the annual “Flagstaff Festival of Science”, a large, university-sponsored community event: 11,700 members of the general public enjoyed hands-on activities, demonstrations, displays and presentations celebrating all things STEM. “ASU’s Space Grant Intern and Fellow Community Outreach Program” fosters participation in a variety of community educational events--including Earth and Space Exploration Day, the Arizona SciTech Festival, and more--that helped inform 9883 students, educators and community members in 2013. Each event represents collaborations between many partners including ASU’s School of Earth and Space Exploration (SESE) and members of the greater Phoenix community. “Science Speakers” a program with 34 speakers offering presentations on 73 topics--from “How the brain works”, to “Rocks from Space”, to “Satellite remote sensing and the environment”--serves schools and community organizations in and around Tucson (UA).
6. **Support NASA Applied Science:** All Earth Grant activities support NASA Applied Science.
7. **Evaluate programs’ success via quantitative and qualitative methods (plus longitudinal tracking of graduate fellow/undergraduate intern participants) insure continuous process improvement:** All Earth Grant programs undergo quantitative and qualitative evaluation and review. Graduate Fellow-led programs are evaluated by Space Grant Managers and steering committee members.
8. **Programs leverage NASA funding by >50%:** A NASA base budget investment of \$0 is highly leveraged with Geospatial Specialist Barron Orr committing 5% FTE (\$5,776) to programs at no charge to our grant. Earth Grant program non-federal partners contributed an additional (\$458,689) and other federal sources provided (\$90,961). Other efforts are staffed by Space Grant Interns and Fellows with wages reported under Fellowships; ASU Interns contribute community service hours as part of their Fellowship award obligations.

These and other Informal Education activities contribute directly to AZSGC goals and objectives, to NASA Education Outcomes 1, 2, 3 and NEP 1, 6, 7 and 8. All program area SMART objectives were met.

## **PROGRAM CONTRIBUTIONS TO NASA EDUCATION PERFORMANCE MEASURES**

- **Student Data and Longitudinal Tracking: Student Data and Longitudinal Tracking:** Of 957 AZSGC significant award recipients from 2006 to 2013: 691 have completed degree programs (29 seeking STEM employment are still-to-be tracked). The remaining 662 have taken next steps; of these, 625 (94%) are employed in STEM

fields or are pursuing additional STEM degrees, 174 are employed by NASA, aerospace contractors, universities, and K-12 institutions, 170 are employed in STEM non-aerospace positions, 281 (see note below) are pursuing advanced STEM degree programs. Of the 226 AZSGC 2006-2013 awardees from underrepresented groups: 141 have completed degree programs (11 of these are seeking STEM employment and are still-to-be tracked). Of 130 students who have taken “next steps”, 123 (95%) of the underrepresented graduates are pursuing advanced STEM degrees or are employed in STEM fields. In addition, 46 graduate and undergrad awardees pursued advanced STEM degrees PLUS entered the STEM workforce. To avoid double counting, 44 undergrads and 2 grads, 11 from underrepresented groups, were not counted in the “pursuing advanced STEM degree” category.

- **Diversity:** AZSGC involves Arizona’s four, four-year research universities as members, working with 27 affiliate partners: community colleges (including 5 MSIs/HSIs), federal research organizations, private industry, and for- and not-for-profit research enterprises. The state management team has eleven members, (45% women, one from an underrepresented minority group) representing 9 diverse NASA and educational disciplines. There are 96 Arizona researchers from member and affiliate institutions, from 52 diverse disciplines, serving as FY 2013 research mentors to Space Grant Undergraduate Research Interns. To further grow our nation’s STEM workforce, Space Grant Fellowship awards are not restricted to science/engineering students; non-STEM awardees frequently switch to STEM majors. We meet or exceed ethnic and gender diversity goals for student participants in all program areas except research, where participant numbers reflect the composition of university/college classes, student clubs, etc. Space Grant *funded* students’ diversity in Research significantly exceeds ethnic/racial diversity goals but lags below AZSGC gender diversity targets. A majority of Precollege and public programs are directed to schools/groups with large percentages of underserved populations across Arizona.
- **Minority-Serving Institutions:** AZSGC includes five minority-serving/Hispanic-serving institutions, all community colleges: Pima Community College (PCC), South Mountain Community College (SMCC), Glendale Community College (GCC), Diné (Navajo Tribal) College and Tohono O’odham (Tribal) Community College (TOCC). In FY 2013 they are participating in the following programs (cumulatively addressing Outcomes 1, 2, 3 and NEP1, 4, 7 and 8): Fellowships (UA Undergraduate Research Internship Program)-PCC; Research (ASCEND)-PCC, SMCC, GCC, and Diné will participate Spring 2014; Higher Education (Statewide Symposium)-PCC, SMCC, GCC; (STEM Courses Enhancement)-TOCC; (International Asteroid Search)-Diné.

New and exciting avenues for collaboration are taking place at our Tribal College affiliates in FY 2013. At Diné, their new AZSGC representative made the following request for how to best utilize FY 2013 Space Grant funding and support: “I know this is very general...but would you have certain areas of expertise and people there that could help my teachers incorporate "real, relevant" science into their classrooms? We are so isolated that even having faculty in to present new ideas is stimulating for

the faculty and students....And then if some, if not all, could become classroom activities it would even be better.” In response, we polled AZSGC partners from across the state and received several proposals for experts and programs with associated teacher training, materials and classroom activities to share with Diné. Two were selected: a program on asteroid science (see Higher Education) to be delivered by AZSGC partners from the Mt. Lemmon SkyCenter, the OSIRIS-REx Mission, Catalina Sky Survey and the International Astronomical Search Collaboration (IASC), and an ASCEND-type balloon-sat program (see Research) to be delivered by Arizona Near Space Research (ANSR) and ERAU faculty, both scheduled for spring 2014. These programs represent a significant investment in volunteer time, materials/supplies, and costs beyond the small travel grants provided by AZSGC, demonstrating that the committed and generous AZSGC network of partners thrives! At Tohono O’odham Community College (TOCC), FY 2013 Space Grant support/funding is being used to purchase an array of research tools and supplies to facilitate inclusion of hands-on learning activities in six STEM classes.

#### **NASA Education Priorities:**

- **Authentic hands-on student experiences in science and engineering disciplines rooted in NASA related, STEM-focused questions and issues; incorporation of real life problem-solving and needs as the context for activities:** This priority is addressed through 1) all 124 mentored research internships (Fellowships); 2) NASA research-based outreach programs led by each of 10 Graduate Fellows (see Fellowships, Higher Education, Precollege and Informal Education); and 3) all Research programs.
- **Diversity** of institutions, faculty, and student participants (gender, underrepresented, underserved). See Diversity and Minority Serving Institutions (above).
- **Engage middle school teachers** in hands-on curriculum enhancement capabilities through exposure to NASA scientific and technical expertise. See Precollege programs 1, 2, 8 and 10 (objectives 2 and 3), and build capabilities for teachers to provide authentic, hands-on middle school student experiences in science and engineering disciplines (see above).
- **Summer opportunities for secondary students on college campuses with the objective of increased enrollment in STEM disciplines or interest in STEM careers:** ERAU Rocket Challenge Program (See Precollege program 14, objective 3).
- **Community Colleges – develop new relationships as well as sustain and strengthen existing institutional relationships with community colleges:** See Minority Serving Institutions above.
- **Aeronautics research – research in traditional aeronautics disciplines; research in areas that are appropriate to NASA's unique capabilities; directly address the fundamental research needs of the Next Generation Air Transportation System (NextGen):** ERAU has its roots as an aeronautical university with an emphasis on aviation and aeronautical engineering. ERAU Space Grant supports basic and applied research in

aeronautics. The projects range from basic low-speed aerodynamics studies up to applied research in unmanned aerial systems integration into the national air space. In 2013, 15 AZSGC Undergraduate Research Interns from UA, ASU, NAU and ERAU participated in mentored research on leading-edge aeronautics topics.

- **Environmental Science and Global Climate Change – research and activities to better understand Earth's environments:** In FY 2013, 15 Undergraduate Interns worked with Arizona researchers on Environmental Science/Global Climate Change projects in 2013; an entire topical session at the Statewide Symposium in April 2014 will be dedicated to these topics. Outreach programs led by 4 Graduate Fellows, focused on environmental science/global change subjects (see Precollege and Informal Education), and many projects subsumed under the Earth Grant program are directed to these topics, especially to the effects of desertification and its control.
- **Enhance the capacity of institutions to support innovative research infrastructure activities to enable early career faculty to focus their research toward NASA priorities:** When Internship project proposals are received from researchers starting to build research programs, split-funding requirements are waived (see Fellowships). Participation in our statewide balloon-sat program (see Research) has positively impacted the research infrastructures at three (MSI/HSI) community college affiliates: According to Dr. Tim Frank at SMCC, “SMCC’s initial involvement in the ASCEND Balloon Project has made a huge difference in our engineering program. It led us to create a special projects course and change the focus of many of our other engineering courses to a more hands-on curriculum. It also allowed us to apply for and receive two \$25k grants from the Goodrich Foundation, which expanded the opportunities for our students to work on real-world engineering design projects. Furthermore, we were able to develop an internship program with Honeywell, which provided some of our students with paid internships working on the Orion Spacecraft, while also being a source of revenue for SMCC. This extra money has allowed us to promote and enhance our engineering program in ways that would never have been possible before our involvement with ASCEND.”

## IMPROVEMENTS MADE IN THE PAST YEAR

1. **Management:** Per the NASA Education Office request, we have made a concerted effort to send stories and pictures of AZSGC accomplishments, events and highlights for inclusion in the redesigned, National Space Grant Program website. We are proud to welcome AZSGC alumnus, Dr. Casey Kahn-Thornbrugh, as the new AZSGC affiliate representative at TOCC.
2. **Fellowships Diversity:** Always a goal and a challenge, in 2013 we are conducting a peer STEM engagement study to enhance AZSGC capacity to identify, recruit, engage and insure the success of underrepresented students. Our new approach, conducted with support from UA colleges of Science and Agriculture and Life Science, is to learn from peers what works and what does not

- by engaging in a partnership with LeadLocal, a Tucson SME that specializes in creating solutions for local organizations through a competitive leadership development program involving high-potential interns. LeadLocal recruited a past Space Grant Fellow to mentor six interns (women and underrepresented minorities) who are being trained to conduct a formative, participatory study to engage and learn from current and past underrepresented interns as a means to validate our current approaches and develop new ones, with the potential for success backed by research. The study is timed to be completed and presented at the AZSGC Undergraduate Symposium in April 2014.
3. **Research Infrastructure:** ERAU made a second lab room available to the Space Grant EagleSat (NASA CubeSat) project, doubling the floor space dedicated to the program, and purchased a laminar flow work bench to help to mitigate against contamination of the electronics boards during fabrication and early testing of the hardware. ASU Space Grant recruited new mentors for two team engineering programs: Space Grant Robotics (new mentors Ryan Meuth, Cody Youngbull and Srikanth Saripalli) bring expertise in underwater autonomous sensor networks and autonomous robotics, and the Sun Devil Satellite Laboratory (new mentors, Iman Alizadeh and Jekan Thanga) bring expertise in Space Systems Engineering and Engineering Matter, Transport and Energy. SMCC: see “Enhance the capacity of institutions to support innovative research infrastructure activities...” above.
  4. **Precollege:** There is a growing demand to expand Space Grant outreach into public schools, but achieving classroom access is challenging. In 2013, the ASU Space Grant Associate Director and Coordinator systematically worked to meet and build relationships with local school districts, establishing partnerships with the large Tempe Elementary District 3 (close-by to ASU with many Title 1 schools), the Tempe Union High School District, and have engaged the district’s overall Science Coordinator who is now helping facilitate the reach of SG programs into local elementary, middle, and high schools. NAU Space Grant increased Manager involvement with funded native reservations school programs and participants, to improve and grow efforts serving these communities, while evolving collaborations with AZSGC affiliate Lowell Observatory. NAU’s Senior Coordinator, a teacher, visited reservation classes with the Lowell Navajo/Hopi outreach scientists, attended Lowell’s annual teacher training workshop, and traveled with the AIMER trailer and educator to observe reservation class lessons and a community star party first-hand. She met and built rapport with teachers, and shared information about other AZSGC programs and teacher training opportunities available to them. She is developing a more comprehensive understanding of program operations, which will be especially helpful in facilitating AIMER staff changes when the current educator retires later this year, and in formulating plans for future AIMER program delivery as the aging trailer requires upgrading and/or replacement. New avenues for program sharing and collaborations are also being explored with Lowell and their Education Coordinator. Finally, NAU became a partner of the 4.3 meter Discovery Channel Telescope (DCT) with Lowell, an investment destined to bring significant new research and educational opportunities to Space Grant Research Interns and others.

## **PROGRAM PARTNERS AND ROLE OF PARTNERS IN PROJECT EXECUTION**

### **Members:**

University of Arizona (Lead): State University  
Arizona State University State University  
Northern Arizona University State University  
Embry-Riddle Aeronautical University

### **Affiliate Partners:**

Higher Education Program Partner: Coconino CC  
Higher Education Program Partner: Dine College (Tribal)  
Higher Education Program Partner: Nat'l Undergrad Research Observatory  
Higher Education Program Partner: South Mountain CC (MSI)  
Higher Education Program Partner: Pima CC (Hispanic)  
Higher Education Program Partner: Glendale CC (Hispanic)  
Higher Education Program Partner: Tohono O'odham CC (Tribal)  
Industry Affiliate: AZ Near Space Research  
Industry Affiliate: Iridium Satellite LLC  
Industry Affiliate: Orbital Sciences Corp  
Industry Affiliate: Paragon Space Development Corp  
Industry Affiliate: QinetiQ North America  
Industry Affiliate: Raytheon Corp  
Industry Affiliate: Rincon Research  
Outreach Affiliate: AZ Daily Star  
Outreach Affiliate: AZ Daily Sun  
Outreach Affiliate: Biosphere 2  
Outreach Affiliate: Flandrau Planetarium and Science Center  
Outreach Affiliate: Hungry Planets Systems & Services  
Outreach Affiliate: International Dark-Sky (NPO)  
Outreach Affiliate: Mt. Lemmon Sky Center  
Outreach Affiliate: Prescott Astronomy Club  
Research Partner: Jet Propulsion Laboratory  
Research Partner: Lowell Observatory  
Research Partner: National Optical Astronomy Observatories (Federal)  
Research Partner: Planetary Science Institute (NPO)  
Research Partner: USDA SWRC (Federal)  
Research Partner: USGS, Flagstaff, Tucson (Federal)

**The National Space Grant Office requires two annual reports, the Annual Performance Data Report (APD) and the Office of Education Performance Measurement System (OEPM) report. The former is primarily narrative and the latter data intensive. Because the reporting timeline cycles are different, data in the two reports may not necessarily agree at the time of report submission. OEPM data are used for official reporting.**